



A Dedicated Joint Unmixing and Demosaicing Method for Snapshot Spectral Images

Kinan Abbas, Matthieu Puigt, Gilles Delmaire, Gilles Roussel

► To cite this version:

Kinan Abbas, Matthieu Puigt, Gilles Delmaire, Gilles Roussel. A Dedicated Joint Unmixing and Demosaicing Method for Snapshot Spectral Images. 8ème Journée Régionale des Doctorants en Automatique et Traitement du Signal (JRDA), Jun 2022, Douai, France. hal-03685172

HAL Id: hal-03685172

<https://hal.science/hal-03685172>

Submitted on 13 Jun 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

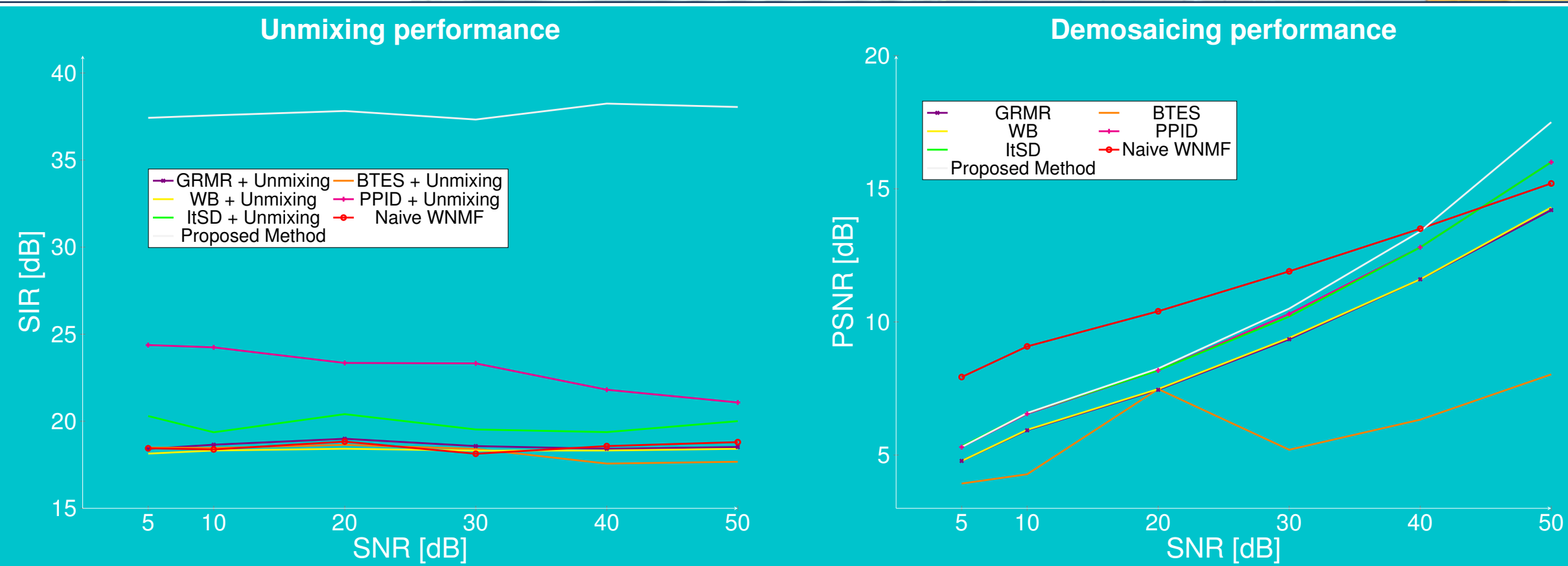
L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

8^{ÈME} JOURNÉE RÉGIONALE DES DOCTORANTS EN AUTOMATIQUE

Mardi 14 Juin 2022 - IMT Nord Europe

IMT Nord Europe
Ecole Mines-Télécom
IMT-Université de Lille

Performing unmixing after demosaicing SSI images is not a good strategy. Instead, unmixing from the SSI data is far better!



A Dedicated Joint Unmixing and Demosaicing Method for Snapshot Spectral Images

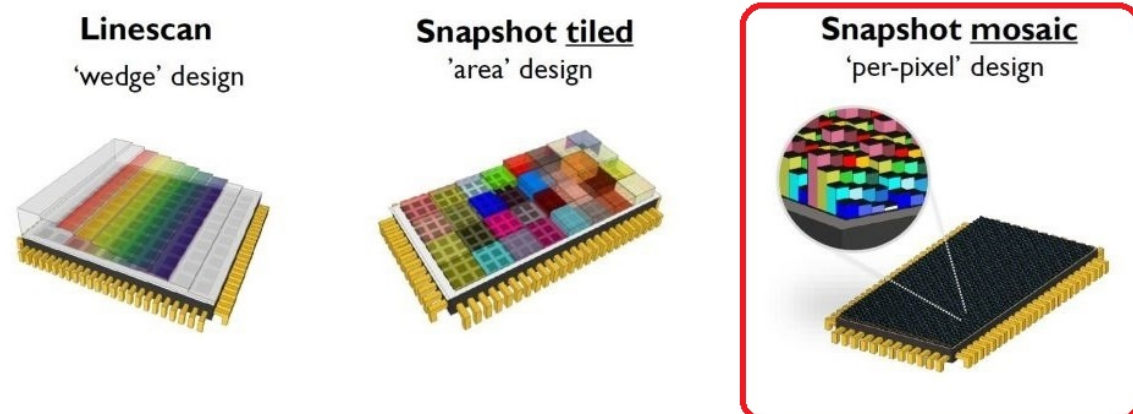
Kinan ABBAS*, Matthieu PUIGT**, Gilles DELMAIRE, Gilles ROUSSEL**

Univ. Littoral Côte d'Opale, LISIC, Longuenesse, prenom.nom@univ-littoral.fr * Doctorant depuis juin 2021 ** Directeurs de thèse



Snapshot Spectral Imaging (SSI)

- Strategies for miniaturized HSI sensors (on the left for images, middle and right for videos – Source IMEC).



- Demosaicing = providing a datacube combining full spectral information & good spatial resolution**
- Various approaches have been proposed:
 - Weighted bilinear interpolation (WB)
 - Iterative Spectral Difference (ItSD)
 - Multispectral demosaicing approach using a pseudo-panchromatic image (PPID)
 - Binary Tree-Based Generic Demosaicing (BTES)
 - Graph and rank regularized method (GRMR)

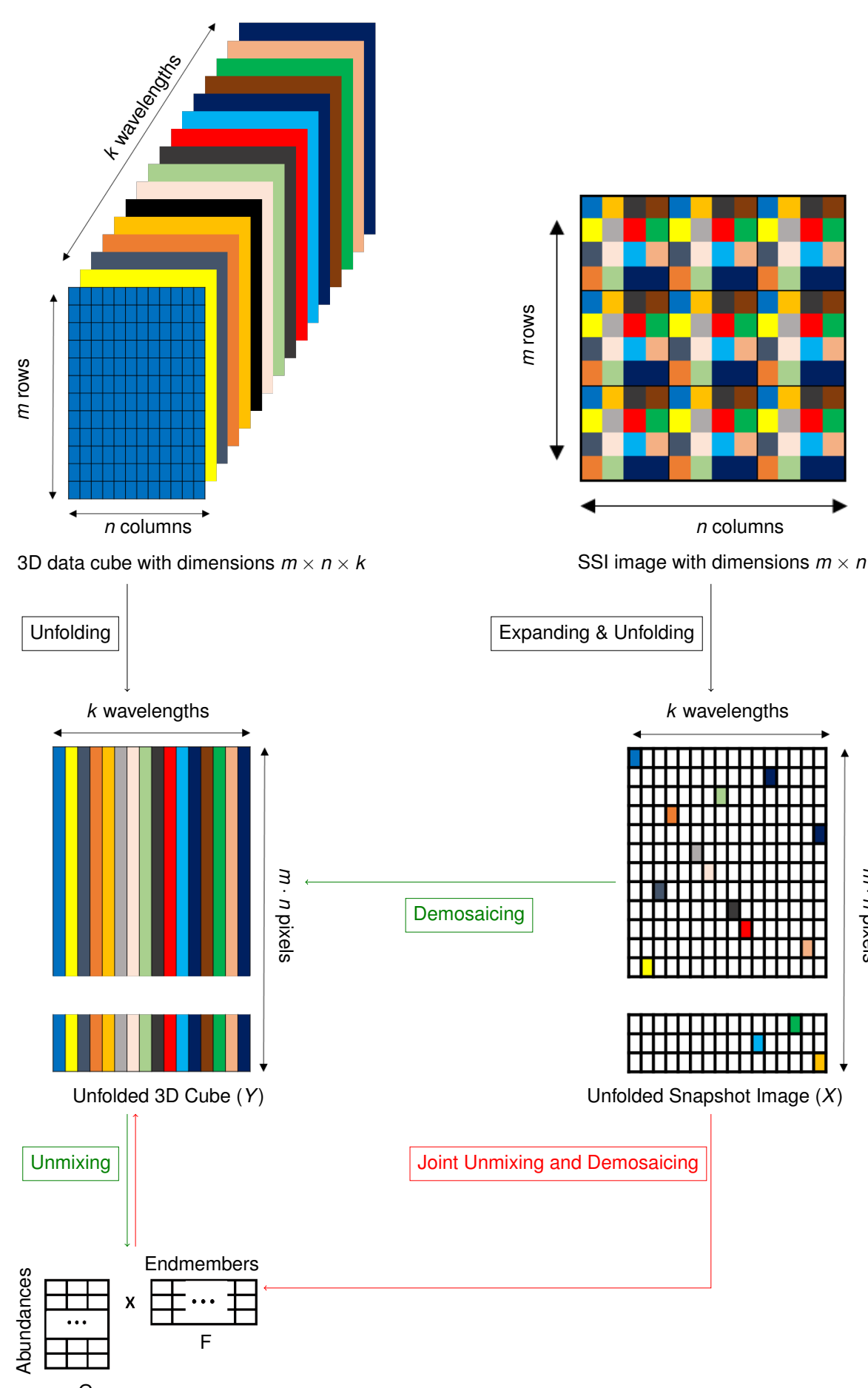


Figure: Principles of the two-step (in green) and joint (in red) strategies.

- ⚠ **Performing classification after demosaicing provides a poor classification performance [1]**

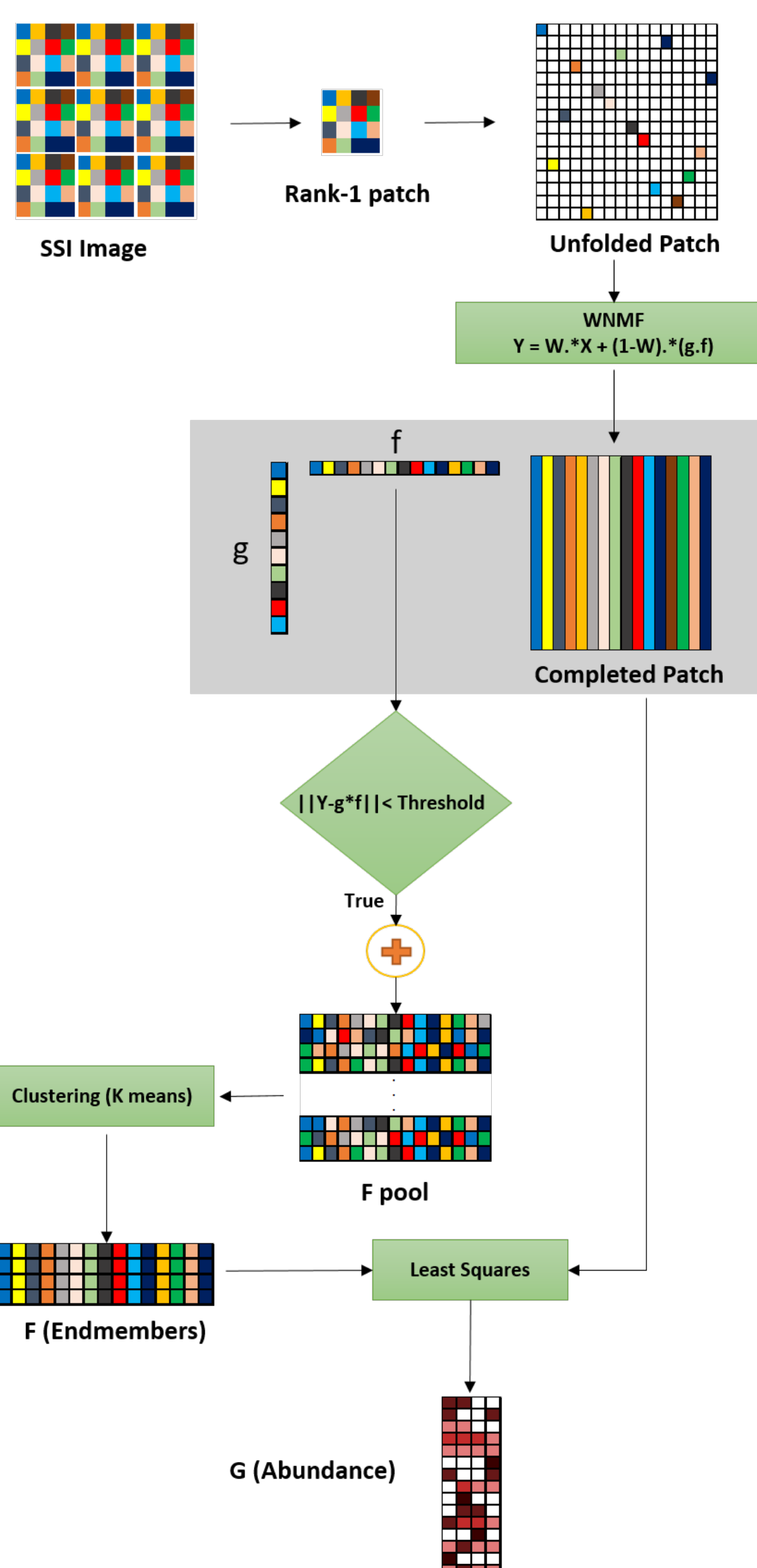
- In [2], **joint** low-rank matrix completion and factorization **far more accurate** than a two-stage approach.
- ⚡ **Joint Demosaicing and Unmixing more efficient than a two-stage approach?**

Naive Method

- Weighted Non-negative Matrix Factorization (WNMF) is used to solve the joint demosaicing and unmixing problem.
- $$\hat{Y} = W \circ X + (\mathbb{1}_{(m,n) \times k} - W) \circ (G \cdot F), \quad (1)$$
- W denotes a binary weight matrix whose nonzero entries allow to select which wavelength is observed by the camera in the case of ideal filter.
 - W denotes the contributions of each wavelength in the observed wavelength in the case of the real filter.
 - Can be solved using Expectation Maximization WNMF framework [3].

Proposed Low-rank Completion-Based Method

- Patch-based rank-1 completion WNMF method (KPWNMF) [4]
 - Assumes some local abundance sparsity
 - Finds locally rank-1 patches which correspond to almost "pure patches"
 - Assumption recently relaxed [5]



Real Filter Harmonics Problem

- Fabry-Perot filters introduce additional harmonics around each wavelength of interest in real implementation.
- These filters are known and are provided by the camera manufacturers.
- Our proposed method takes these harmonics into consideration.

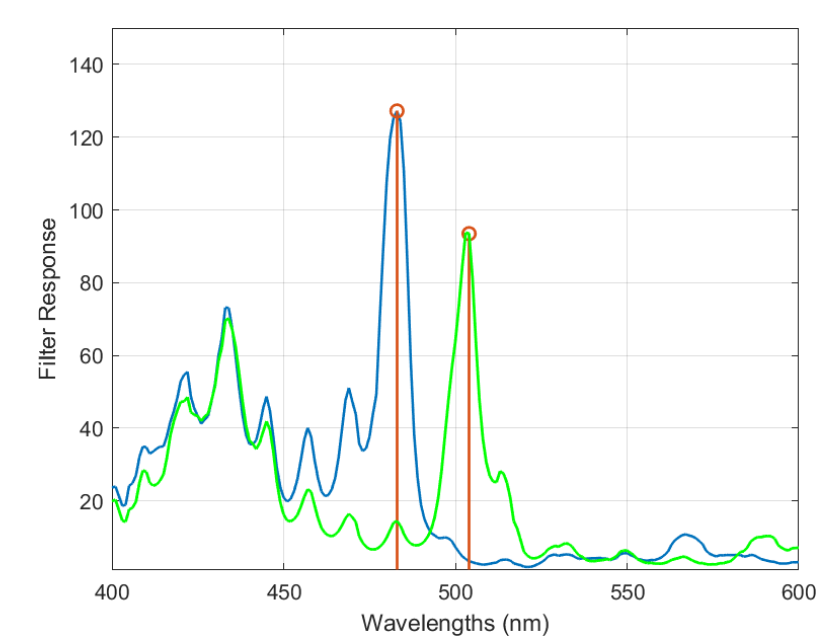


Figure: Ideal (in red) and real (in blue and green) spectral response of two Fabry-Perot filters of the 4 × 4 IMEC SSI camera.

Experiment and Results

- To validate the performance of the proposed approach, we conduct an experiment on Jasper Ridge image.
- We assume that the hyperspectral imagery is acquired using a SSI camera system, equipped with 5 × 5 and 4 × 4 spectral filter patterns.
- Simulations assuming an ideal and real snapshot mosaic filters.
- Reconstruction quality is measured in terms of Peak Signal-to-Noise Ratio (PSNR, in dB) while the unmixing enhancement is measured using Signal-to-Interference Ratio (SIR, in dB).
- Far better unmixing performance** reached by our proposed approach than with 2-stage techniques and naive WNMF
- Still **demosaicing similar** or slightly better than SotA methods

Conclusion and Future Work

- The proposed method provides a slightly better demosaicing performance than state-of-the-art methods and a much higher unmixing enhancement.
- We aim to investigate the use of our proposed methods on real SSI data.
- We also aim to extend them to the case when endmember spectral variability is met in the acquisition process.

Acknowledgements and References

This work was partly funded by the Région Hauts-de-France. Experiments presented in this work were carried out using the CALCULCO computing platform, supported by SCoSI/ULCO.

- G. Tsagkatakis, M. Bloemen, B. Geelen, M. Jayapala, and P. Tsakalides. "Graph and Rank Regularized Matrix Recovery for Snapshot Spectral Image Demosaicing". In: *IEEE Trans. Comput. Imaging* 5:2 (June 2019), pp. 301–316.
- C. Dorfler, M. Puigt, G. Delmaire, and G. Roussel. "Informed nonnegative matrix factorization methods for mobile sensor network calibration". In: *IEEE Trans. Signal Inf. Process. Netw.* 4:4 (2018), pp. 667–682.
- C. Dorfler, M. Puigt, G. Delmaire, and G. Roussel. "Fast Nonnegative Matrix Factorization and Completion Using Nesterov Iterations". In: *Proc. LVA/ICA'17*, Vol. 10169. LNCS. Feb. 2017, pp. 26–35.
- K. Abbas, M. Puigt, G. Delmaire, and G. Roussel. *Méthode de démixage et de matricage conjoints fondée sur la complétion de rang un pour les images multispectrales « snapshot »*. to appear in GREST'22.
- K. Abbas, M. Puigt, G. Delmaire, and G. Roussel. *Filtering-Based Endmember Identification Method for Snapshot Spectral Images*. to appear in Proc. WHISPERS'22.